THE OCCURRANCE OF POLYCHLORINATED BIPHENYLS (PCBS) IN THE ROANOKE AND DAN RIVERS

A PRELIMINARY REPORT

JERRY WALLMEYER,BIOLOGIST
VIRGINIA STATE WATER CONTROL BOARD

FEBRUARY, 1973

PREFACE

In February 1971 the Virginia General Assembly passed House Joint Resolution 51 which directed that a statewide program be initiated by the Virginia Department of Agriculture and Commerce to determine the extent of the presence of pesticides in the environment. The State Water Control Board participated in that study with VDAC and other agencies and collected samples of water and fish from March to August 1971.

During the analytical phase of this Pesticide Study the presence of Polychlorinated Biphenyls (PCBs), a chlorinated hydrocarbon, was noted in some fish samples which had been taken from the Roanoke River.

In order to determine to what extent PCBs were present in the Roanoke River Basin, the Board initiated a comprehensive study which would greatly expand the number of stations which had been sampled for the Pesticide Study. Fish and sediment samples were collected in parts of the Roanoke and Dan Rivers and Leesville and Kerr Reservoirs. The following report will deal with the results of this phase of the Study and is in fact a preliminary report. A future report will contain additional information in the form of results of surveys of domestic and industrial wastes as well as additional biological information.

At present there is little information available on the toxic effects of PCBs. The FDA has established a 5.0 ppm maximum allowance concentration in the edible meat of fish. Published in the federal register of March 18, 1972, the FDA reported that "PCBs are toxic substances which are very stable and highly persistent in the environment." The federal register further states that "....the commission of Food and Drugs is taking all reasonable steps to limit the ways in which PCBs may otherwise contaminate food and to limit the level of PCBs in foods containing unavoidable PCB residues from environmental or industrial sources."

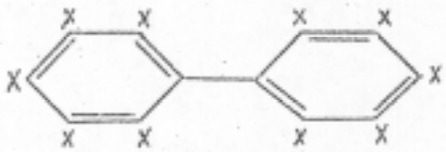
INTRODUCTION

A study of the PCB (Polychlorinated Biphenyls) contamination of part of the Roanoke River Basin was initiated after routine pesticide monitoring of fish taken from that basin in June of 1971 showed apparently high levels of the chlorinated hydrocarbon. The monitoring for pesticides (authorized by House Joint Resolution 51 of the 1970 Virginia General Assembly to ascertain the extent of pesticides in both fish and water) was conducted cooperatively by the Commission of Game and Inland Fisheries, State Water Control Board, and the Department of Agriculture and Commerce from March to August 1971.

Chemistry

PCBs are manufactured in this country by the Monsanto Company; and are usually identified by the trade name Aroclor and a four-number suffix, such as Aroclor 1254. The first two digits of the suffix designate the compound as a pure biphenyl (as opposed to a terphenyl or a blend of biphenyl and terphenyl), and the last two digits of the suffix designate the weight per cent chlorine (Peakall & Linder, 1970). PCBs are also produced in Europe and Japan under such names as Phenochlor and Clophen (Gustafson, 1970).

PCBs are simply biphenyls which have two or more chlorine atoms substituted for hydrogen atoms. The chlorine atoms may occupy any of the positions marked "X". Aroclor 1242 has an average of three chlorine atoms on the molecule.



PCBs are considered chemically inert, insoluble in water, very soluble in hydrocarbon solvents, and resistant to alkalies, acids, and corrosive chemicals. Among other things PCBs are used as plasticizers for adhesives, polyvinyl acetates, acrylic resins, in sealing compounds, pipe joint compounds, rubber manufacturing, high pressure-high temperature lubricants, fungicidal insulations, nail coatings, water proofings, diffusion pump fluid, stablization of polymers, dielectrics, heat transfer media, coax-cable insulations, paints and varnishes, ice-preventing coatings, and as an evaporation retardant for pesticide applications (Veith & Lee, 1970). It was also reported that PCBs are apparently used in the paper coating process and the micro-encapsulation process (Kroner 1971).

Biology

Little is known of the biological decomposition of PCBs, but it is likely that they are more stable than DDT since they lack the ethane component between the aromatic rings, which is the site of action for most of the transformations of DDT (Peakall & Linder, 1970). Work done by Keil et al. (1971) with *Cylindrotheca closterium* demonstrated the ability of the marine diatom to concentrate PCB up to 1100 times the level added to the culture media. Stalling (1971), working with bluegills and channel catfish, was able to show concentration factors ranging from 26,300 to 52,000 in an 11-week test exposure to Aroclor 1248 and Aroclor 1254 ranging from 6-14 ug/l. Thus

INTRODUCTION

A study of the PCB (Polychlorinated Biphenyls) contamination of part of the Roanoke River Basin was initiated after routine pesticide monitoring of fish taken from that basin in June of 1971 showed apparently high levels of the chlorinated hydrocarbon. The monitoring for pesticides (authorized by House Joint Resolution 51 of the 1970 Virginia General Assembly to ascertain the extent of pesticides in both fish and water) was conducted cooperatively by the Commission of Game and Inland Fisheries, State Water Control Board, and the Department of Agriculture and Commerce from March to August 1971.

Chemistry

PCBs are manufactured in this country by the Monsanto Company; and are usually identified by the trade name Aroclor and a four-number suffix, such as Aroclor 1254. The first two digits of the suffix designate the compound as a pure biphenyl (as opposed to a terphenyl or a blend of biphenyl and terphenyl), and the last two digits of the suffix designate the weight per cent chlorine (Peakall & Lincer, 1970). PCBs are also produced in Europe and Japan under such names as Phenochlor and Clophen (Gustafson, 1970).

PCBs are simply biphenyls which have two or more chlorine atoms substituted for hydrogen atoms. The chlorine atoms may occupy any of the positions marked "X". Aroclor 1242 has an average of three chlorine atoms on the molecule.

PCBs are considered chemically inert, insoluble in water, very soluble in hydrocarbon solvents, and resistant to alkalies, acids, and corrosive chemicals. Among other things PCBs are used as plasticizers for adhesives, polyvinyl acetates, acrylic resins, in sealing compounds, pipe joint compounds, rubber manufacturing, high pressure-high temperature lubricants, fungicidal insulations, nail coatings, water proofings, diffusion pump fluid, stablization of polymers, dielectrics, heat transfer media, coax-cable insulations, paints and varnishes, ice-preventing coatings, and as an evaporation retardant for pesticide applications (Veith & Lee, 1970). It was also reported that PCBs are apparently used in the paper coating process and the micro-encapsulation process (Kroner 1971).

Biology

Little is known of the biological decomposition of PCBs, but it is likely that they are more stable than DDT since they lack the ethane component between the aromatic rings, which is the site of action for most of the transformations of DDT (Peakall & Lincer, 1970). Work done by Keil et al. (1971) with *Cylindrotheca closterium* demonstrated the ability of the marine diatom to concentrate PCB up to 1100 times the level added to the culture media. Stalling (1971), working with bluegills and channel catfish, was able to show concentration factors ranging from 26,300 to 52,000 in an 11-week test exposure to Aroclor 1248 and Aroclor 1254 ranging from 6-14 ug/l. Thus

PCBs have the physical and chemical characteristics for persistence and accumulation in the food chain similar to that which has been demonstrated with DDT.

Work that has been done with PCBs suggest that these compounds are two to three orders of magnitude less toxic to fish than DDT. Schoettger (unpublished) found that the 96 hr. TL_m for Aroclor 1221 using cutthroat trout was 1.2 mg/l and for Aroclor 1260 the TL_m was 60.9 mg/l. It was noted that the toxicity of the Aroclor was inversely proportional to their percentage chlorination and was directly proportional to their solubilities (Peakall & Lincer, 1970).

Duke (1971) reported retarded growth of young oysters, *Crassostrea virginica*, reared in flowing seawater containing 5.0 ppb Aroclor. Juvenile pinfish, *Lagodon rhomboides*, and adult mosquito fish, *Gambusia affinis.*, were subjected to acute toxicity tests using Aroclor 1254. In the 48-hour period pinfish survived up to 100.0 ppb and the mosquito fish survived up to 10,000 ppb. But in chronic toxicity tests pinfish and spott, *Leiostromous xanthurus*, died when exposed for 14-45 days at 5.0 ppb. Duke et al. (1970) reported that 5.0 ppb Aroclor 1254 killed 18 to 25 juvenile shrimp, *Penaeus duorarum*, in a 20-day bioassay.

Literature indicates that little is known of the effects of PCBs on humans, but Peakall and Lincer (1970) state that it appears that the lower vertebrates and invertebrates are less susceptible than mammals to direct toxicity from PCBs.

As with DDT, the Food and Drug Aministration has set a 5.0 ppm PCB guideline on edible meat of fish which is to be shipped in interstate commerce (FDA,1972).

Geography

The Roanoke River Basin in Virginia is composed primarily of two streams - the Roanoke River (in some localities known as the Staunton River) and the Dan River (see Figure 1). This study thus far has been concerned with the Roanoke River from Leesville Lake area to the Kerr Lake and with the Dan River from above Danville (below the confluence with the Smith River) to Kerr Lake.

The Roanoke River Basin lies basically on an east-west axis along the southern boundry of Virginia, an area composed primarily of deciduous forest, small farms, and a few industrially-oriented communities. The river rises in the mountains of Montgomery, Roanoke, Bedford, and Franklin Counties and flows out of the state just below the John Kerr Dam near Clarksville.

METHODOLOGY

Sediment Sampling, Preparation, and Analysis

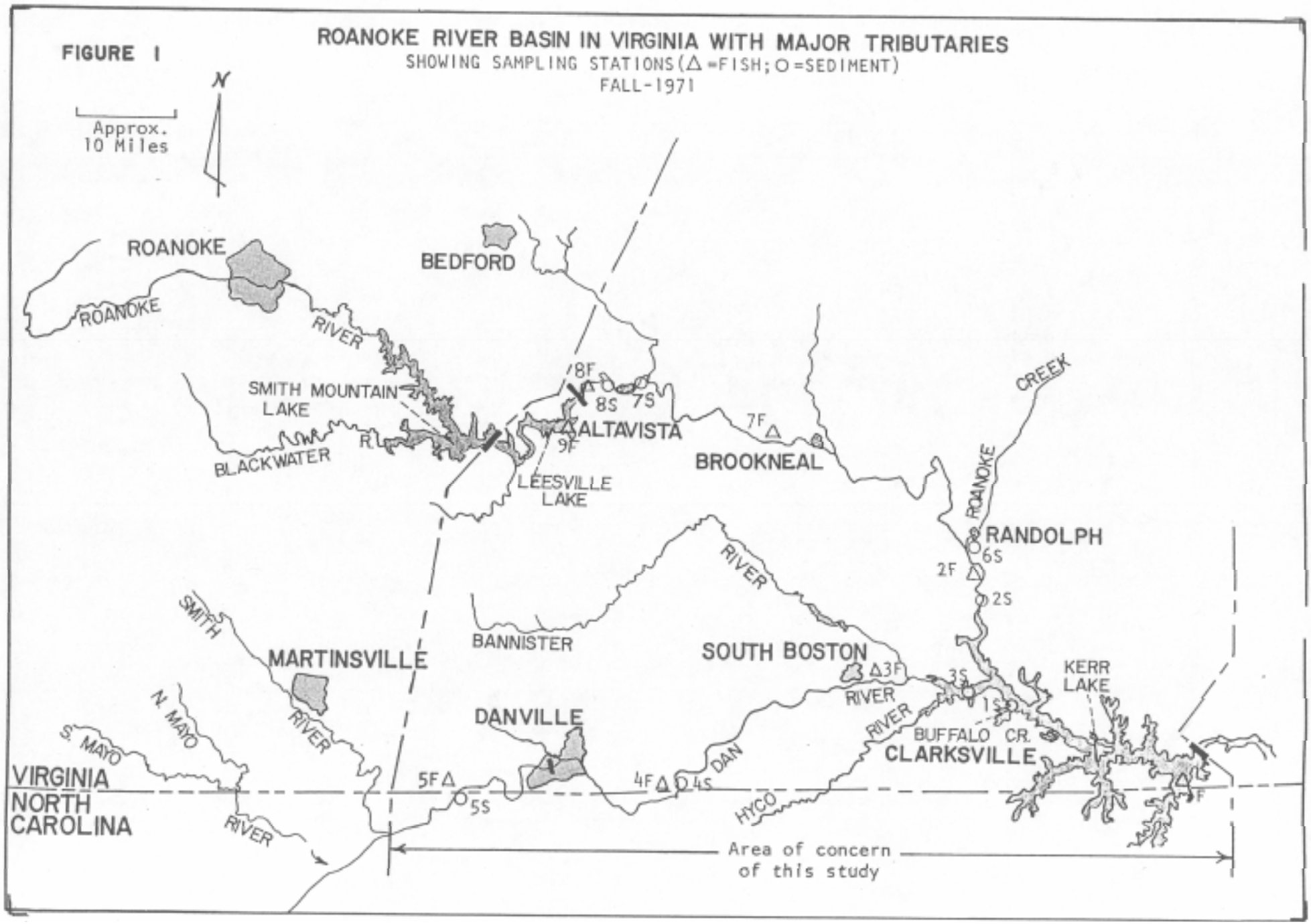
Sediment samples were collected in an attempt to determine the source of PCB, its history of deposition, and the extent of contamination. Samples were collected using a modified frozen core sampler by driving a cylindrical sampling tube into the streambed, sealing the top of the tube, and extracting a core of sediment. Two cores were collected at each station. Following extraction, the cores were frozen by packing dry ice around the sampling tube, transported to the Richmond office, and cut into three one-inch increments; top inch, second inch, and third inch. The samples from each core were composited by inch and by station, placed in clean glass jars, labeled, and

FIGURE 1

ROANOKE RIVER BASIN IN VIRGINIA WITH MAJOR TRIBUTARIES

SHOWING SAMPLING STATIONS (△ = FISH; ○ = SEDIMENT)

FALL-1971



carried to the Residue Lab of the Department of Agriculture and Commerce for analysis.

The lab preparation of the sediment sample consisted of drying at room temperature, mixing 1:1 with filter-cel and soxhlet extraction for 30 hours using Hexane-Acetone. The extract was then evaporated and run through a florisil clean-up column. Two dilution fractions were obtained.

Fraction A, using Methylene Chloride and
Fraction B, using $C_2H_2Cl_2$ and Acetonitrile in hexane.

The prepared sample was then injected into one of the following columns:

5% SE 30 on chromasorb HP
OV-1 on Gas Chrom Q (80-100 mesh)
OV-210 on Gas Chrom Q (80-100 mesh)
OV-17 on Gas Chrom Q (80-100 mesh)

Each of the columns is 6 foot by 1/4 inch. The detection apparatus was a Dohrman Micro-Coulimeteric Titration System.

Sediment samples were collected from both the Roanoke and Dan River arms of the Roanoke River Basin. (Figure 1). Sampling station descriptions are shown in Table 1.

Table 1. SEDIMENT SAMPLING STATION DESCRIPTION

Station	River Mile (Approx.)	Description
1S Kerr Lake	ROA 43	Below the confluence of the Dan and Roanoke River, just above the confluence with Buffalo Creek
2S Roanoke River	ROA 60	Rt. 92 bridge, near Clover, Va.
3S Dan River	DAN 4	300 yards below confluence with Hyco River
4S Dan River	DAN 43	Rt. 62 bridge, near Milton, N.C.
5S Dan River	DAN 75	Rt. 880 bridge, near Brosville, Va.
6S Roanoke Creek	ROC 1	Just below Randolph, Va.
7S Roanoke River	ROA 114	Rt. 640 bridge, below Altavista, Va.
8S Roanoke River	ROA 120	Off Rt. 924, Altavista, Va.

Fish Sampling, Preparation, and Analysis

Fish collections were made by both the Fish Division of the Commission of Game and Inland Fisheries and the Biology Section of the Water Control Board using shocking (electro-fishing) equipment.

*River miles are plotted from the River Mouth upstream, i.e. ROA 43 is 43 miles upstream on the Roanoke River from its mouth.

Following collection, the fish were wrapped in aluminum foil, sealed in plastic bags, labelled, and put on ice. After transport to Richmond, the fish were "dressed" similar to that which is commonly done in preparing a fish for the frying pan, i.e., head, fins, scales, and visceral material were removed. In the case of the catfish the skin was also removed.

The material to be analyzed (edible meat and part of the axial skeleton) was then re-wrapped in aluminum foil, labelled, frozen, and carried to the Residue Lab.

Lab preparation of the fish sample consisted of grinding the fish with dry ice, blending the ground fish with H_2O- acetonitrile in hexane, filtering, and a florisil column clean-up. Further extraction and detection procedures were the same as that for sediment.

Whenever possible the fish samplings and the sediment samplings were made at the same place. Stations 1F, 3F, 7F, and 8F differ slightly from the sediment sampling stations, with an additional station, Station 9F, added to serve as a control (see Figure 1). Because of the relatively small amount of PCB detected in the sediment at Station 6S this tributary was deemed to be an insignificant contributor of PCBs; therefore no fish sampling was made at this station. Although fish are motile and in some cases migratory, an attempt was made to keep the sampling area as small as possible, certainly covering less than 1/2 river mile. The fish sampling stations are shown in Table 2.

Table 2. FISH SAMPLING STATIONS

Station	River Mile (Approx.)	Description
1F Kerr Lake	GRA 0.5	Grassy Creek area
2F Roanoke River	ROA 60	Rt. 92 bridge, near Clover, Va.
3F Dan River	DAN 12	Below William M. Tuck Airport, near South Boston, Va.
4F Dan River	DAN 43	Rt. 62 bridge near Milton, N.C.
5F Dan River	DAN 75	Rt. 880 bridge, near Brosville, Va.
6F NO FISH COLLECTED		
7F Roanoke River	ROA 100	Above Brookneal, Va.
8F Roanoke River	ROA 128	Leesville Tail Race
9F Leesville Lake	OWC 1	Old Woman's Creek area

Throughout this report the common names of fishes are used. The following is a listing of common names and scientific names for the fish taken for tissue analysis in this study.

redhorse sucker	*Moxostoma sp.*
white sucker	*Catostomus commersoni*
channel catfish	*Ictalurus punctatus*
yellow bullhead	*Ictalurus natalis*
carp	*Cyprinus carpio*
largemouth bass	*Micropterus salmoides*
bluegill	*Lepomis macrochirus*
pumpkinseed	*Lepomis gibbosus*
redbreast sunfish	*Lepomis auritus*

RESULTS

Sediment PCB Concentrations

The results of the PCB analyses of the sediment can be found below in Table 3 and in Figure 2. The type of PCB, either Aroclor 1242, 1248, or 1254, is shown with the quantitative value.

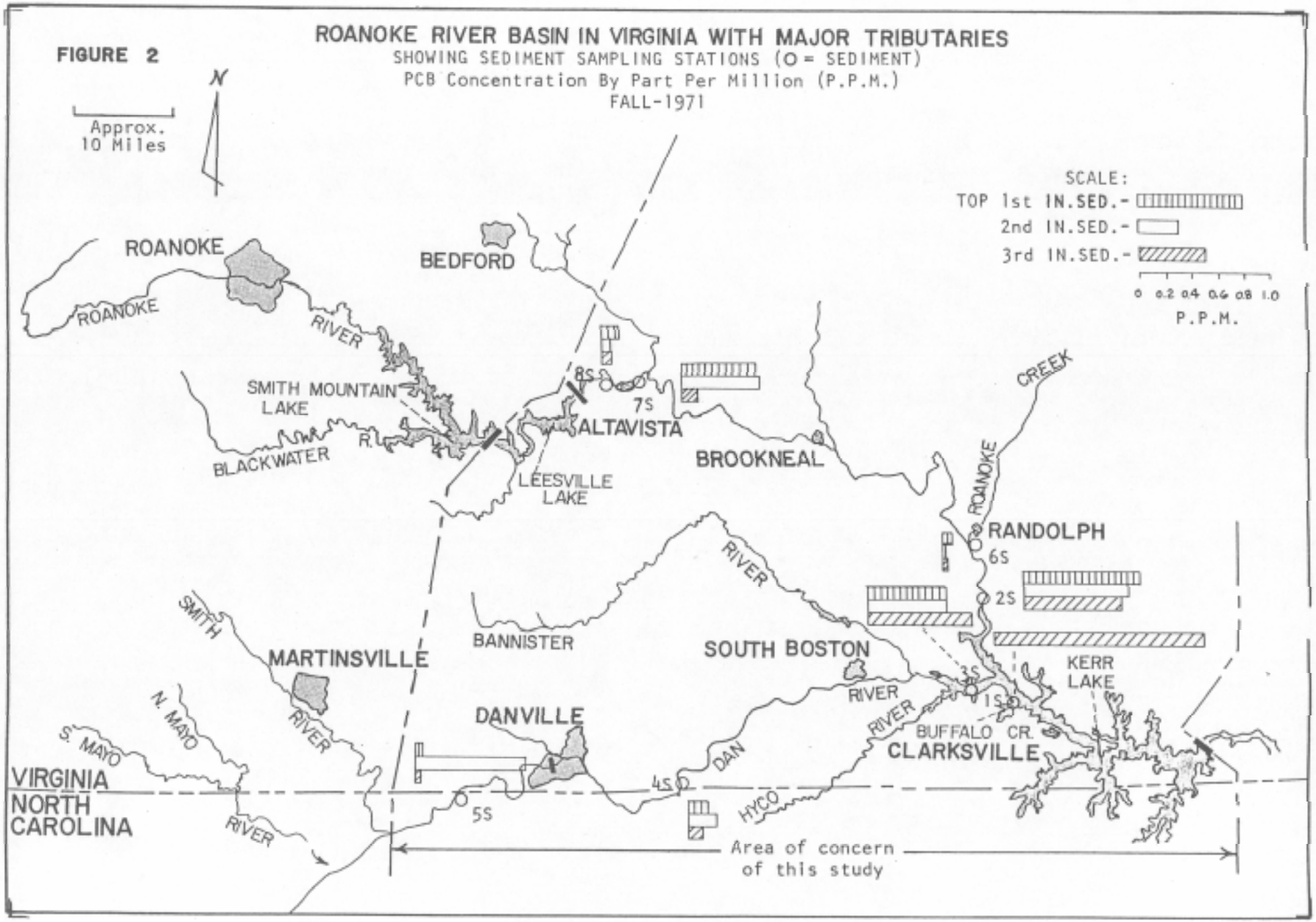
Table 3. Sediment Samples: PCB Analysis (ppm)

Station	Sediment Depth	Aroclor 1242	Aroclor 1248	Aroclor 1254
		Kerr Lake		
1S	Top inch	--	--	--
	2nd inch	--	--	--
	3rd inch	1.6	--	--
		Roanoke River and Roanoke Creek		
2S	Top inch	--	0.9	--
	2nd inch	--	0.8	--
	3rd inch	--	0.75	--
6S	Top inch	--	0.02	0.05
	2nd inch	--	--	0.02
	3rd inch	--	--	0.03
7S	Top inch	--	0.56	--
	2nd inch	--	0.6	--
	3rd inch	--	0.12	--
8S	Top inch	--	0.13	--
	2nd inch	--	0.06	--
	3rd inch	--	0.07	--
		Dan River		
3S	Top inch	0.6	--	--
	2nd inch	0.6	--	--
	3rd inch	0.8	--	--
4S	Top inch	--	0.15	--
	2nd inch	--	0.22	
	3rd inch	--	0.12	--
5S	Top inch	--	0.01	0.06
	2nd inch	--	0.25	0.6
	3rd inch	--	0.02	0.03

FIGURE 2

ROANOKE RIVER BASIN IN VIRGINIA WITH MAJOR TRIBUTARIES

SHOWING SEDIMENT SAMPLING STATIONS (O = SEDIMENT)
PCB Concentration By Part Per Million (P.P.M.)
FALL-1971



Eight stations were selected as sediment sampling stations, and were sampled in the top three inches of sediment by 1-inch increments, thereby yielding twenty-four samples. Of those twenty-four samples, two contained No Detectable (ND) PCB, while four contained 1242, sixteen contained 1248, and six contained 1254. The sum of these "positive" samples is in excess of the original twenty-four samples because four of the samples contain combinations of two types of Aroclors. Table 4 contains a break-down of the different types of Aroclors found within the study area of the basin.

Table 4. Percentage of Sediment Samples Showing the Different Types of Aroclors

Aroclor	Basin Study Area	Roanoke River*	Dan River
1242	4 samples 17%	0 samples 0%	3 samples 33%
1248	16 samples 67%	9 samples 100%	6 samples 67%
1254	6 samples 25%	0 samples 0%	3 samples 33%
ND	2 samples 8%	0 samples 0%	0 samples 0%

*Excluding Roanoke Creek, a tributary

The Roanoke River shows consistently increasing amounts of PCB in the sediment as one approaches the Kerr Lake. It is interesting to note that the 1248 is the only Aroclor found in the samples from the Roanoke River while very small amounts of PCB (1248 and 1254, primarily the latter) were found in Roanoke Creek, a tributary.

With the exception of the second inch of sediment at Station 5S the Dan River shows similarly increasing amounts of PCB as one approaches the reservoir. If the second inch values are omitted from the calculation of the average sediment PCB at Station 5S the average then becomes .06 ppm, a figure comparable to Station 8S on the Roanoke River.

The Dan River samples show that a different Aroclor dominates at each station. Both 1254 and 1248 (predominately 1254) are found at Station 5S, above the dam in Danville, while 1248 dominates at Station 4S, then 1242 at Station 3S.

The one sample collected from the reservoir contained PCB only in the third inch. It is, of course, not possible to speculate as to the meaning of the results of the one sample.

Fish PCB Concentrations

The results of the PCB analyses of the fish tissues can be found below in Table 5. Whenever possible the type of PCB, either Aroclor 1252, 1248, or 1254, is shown beside the quantitative value. See Figure 3 for sampling station locations and average PCB concentration (ppm) by fish type and by sampling station.

By grouping the types of fish (suckers, catfish, carp, bass, and *Lepomis*) it is possible to compare the extent of contamination of the different trophic levels at each station.

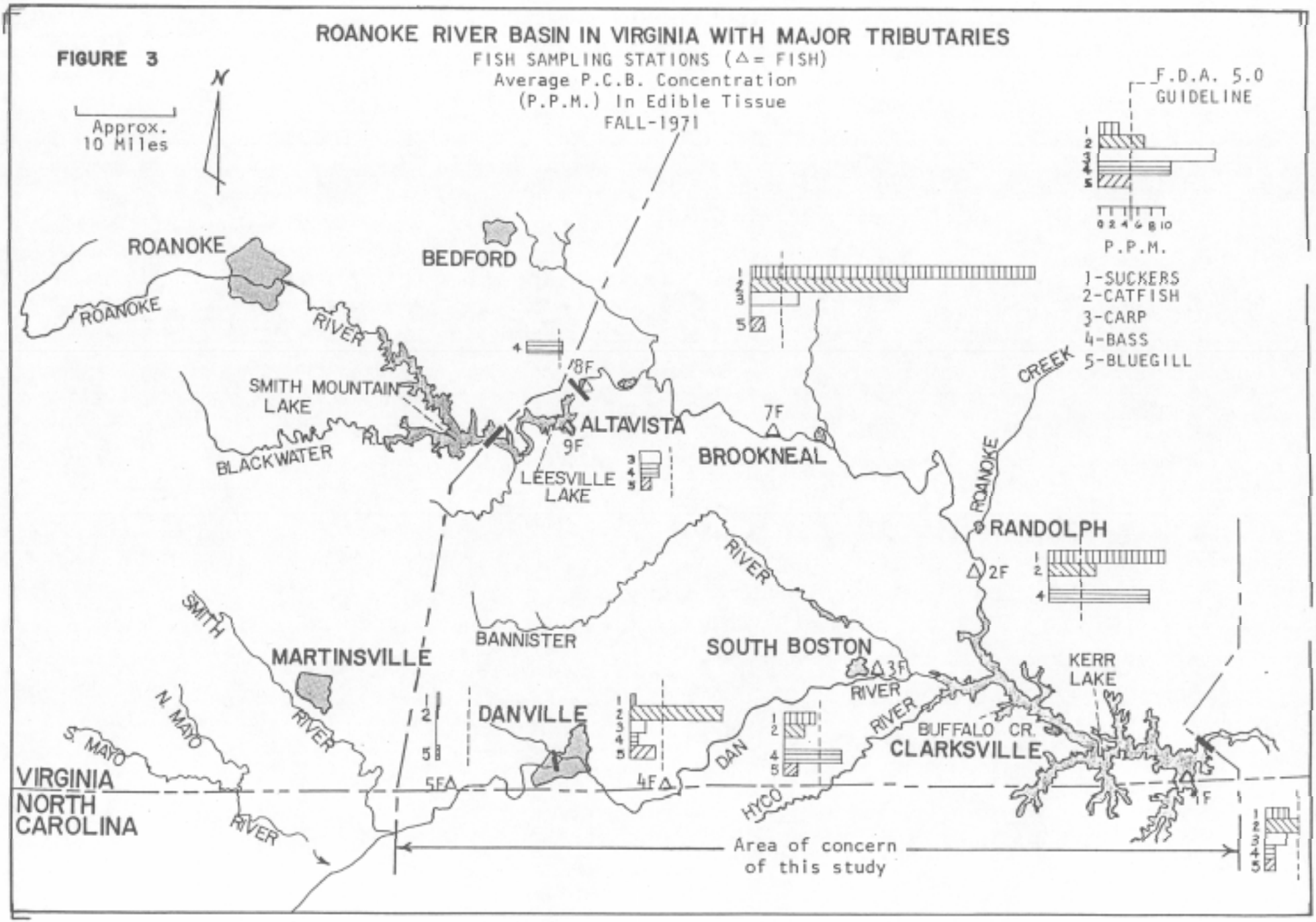
In theory, following biological magnification of chlorinated hydrocarbons, the fish which are higher in the food chain should concentrate more PCB than the fish which are lower in the food

Table 5. Fish Tissue Samples for PCB Analysis (ppm) showing Percentage of Samples Exceeding 5.0 ppm Guideline

Station	Sample	PCB (ppm)	Aroclor
	Kerr Lake		
1F	3 redhorse suckers composite	3.6	1254
	1 channel catfish	11.0	1254
	3 channel catfish composite	2.0	1254
	3 channel catfish composite	2.0	1254
	3 carp composite	3.5	1254
	1 largemouth bass	1.2	1254
	2 largemouth bass composite	3.3	1254
	2 largemouth bass composite	1.0	1254
	4 *Lepomis* composite*	1.4	1254
	4 *Lepomis* composite	0.14	1248
		0.18	1254
	4 *Lepomis* composite	4.8	1254
	4 *Lepomis* composite	0.60	1254
	Roanoke River		
2F			
100% violation	3 redhorse suckers composite	18.0	1248
	3 channel catfish composite	7.1	1248
	3 largemouth bass composite	15.2	1248
7F			
80% violation	1 redhorse sucker	7.5	1248 & 54
	1 white sucker	80.	1254
	3 channel catfish composite	24	1248 & 54
	1 carp	7.5	1248 & 54
	1 *Lepomis*	2.1	1248 & 54
8F			
17% violation	1 largemouth bass	2.0	1254
	1 largemouth bass	0.58	1248
		2.8	1254
	1 largemouth bass	1.1	1254
	1 largemouth bass	28.	1254
	1 largemouth bass	0.38	1254
	1 largemouth bass	4.5	1254
	Leesville Lake		
9F			
10% violation			
	1 carp	0.8	1254
	1 carp	7.2	1254

* *Lepomis* includes bluegill, pumpkinseed, and redbreast sunfish

Station	Sample	PCB (ppm)	Aroclor
	Leesville Lake (cont.)		
	3 carp composite	1.4	1254
	1 largemouth bass	3.2	1254
	1 largemouth bass	2.2	1254
	3 largemouth bass composite	none detectable	
	3 *Lepomis* composite	1.4	1254
	4 *Lepomis* composite	0.4	1254
	4 *Lepomis* composite	3.1	1254
	2 gizzard shad composite	1.4	1254
	Dan River		
3F			
33% violation	2 redhorse suckers composite	3.5	1248 & 54
	2 redhorse suckers composite	5.3	1248 & 54
	2 channel catfish composite	5.0	1248 & 54
	2 channel catfish composite	1.1	1248 & 54
	1 largemouth bass	11.0	1254
	1 largemouth bass	10.0	1254
	1 largemouth bass	4.2	1254
	3 *Lepomis* composite	2.0	1248 & 54
	4 *Lepomis* composite	1.9	1248 & 54
4F			
22% violation	1 white sucker	0.08	1242
		0.85	1254
	2 bullheads composite	0.78	1242
		13.3	1254
	1 carp	0.07	1242
		0.02	1254
	1 carp	5.0	1254
	1 largemouth bass	0.08	1242
		1.6	1254
	1 largemouth bass	0.07	1242
		1.1	1254
	2 *Lepomis* composite	0.15	1242
		2.2	1254
	2 *Lepomis* composite	7.9	1254
		0.15	1242
5F		1.4	1254
0% violation	1 redhorse sucker	0.42	1254
	1 channel catfish	0.80	1254
	2 bullheads composite	0.23	1254
	2 *Lepomis* composite	0.55	1254
	3 *Lepomis* composite	0.32	1254


ROANOKE RIVER BASIN IN VIRGINIA WITH MAJOR TRIBUTARIES
FIGURE 3
FISH SAMPLING STATIONS (△ = FISH)
Average P.C.B. Concentration
(P.P.M.) In Edible Tissue
FALL-1971
N
Approx.
10 Miles
F.D.A. 5.0
GUIDELINE
0 2 4 6 8 10
P.P.M.
1-SUCKERS
2-CATFISH
3-CARP
4-BASS
5-BLUEGILL
ROANOKE
BEDFORD
ROANOKE
RIVER
SMITH MOUNTAIN
LAKE
BLACKWATER
RIVER
8F
ALTAVISTA
9F
7F
BROOKNEAL
CREEK
ROANOKE
LEESVILLE
LAKE
RANDOLPH
2F
RIVER
BANNISTER
SOUTH BOSTON
3F
KERR
LAKE
SMITH
MARTINSVILLE
RIVER
N. MAYO
S. MAYO
DANVILLE
DAN
RIVER
BUFFALO CR.
CLARKSVILLE
VIRGINIA
NORTH
CAROLINA
5F
4F
1F
HYCO
RIVER
Area of concern
of this study

chain. But this trend does not appear in this study; when it is possible to compare PCB levels in fish at a station (i.e., omitting Station 6F and 8F) it is seen that the suckers, catfish, and carp contain higher levels of PCBs than do bass and *Lepomis* in 5 out of 7 cases (Table 6).

Of the 59 samples (representing 119 fish) of edible fish tissue submitted for analysis (either as single fish or as a composite sample) only one showed No Detectable (ND) PCB, while three contained various levels of only 1248, and the remaining 55 contained 1254 either solely or mixed with 1252 or 1248. Table 7 shows a breakdown of the different types of Aroclors found within the basin study area.

Table 6. Average PCB Concentration (ppm) and Number of Fish Analyzed by Fish Type and by Station.

Station	Suckers**		Catfish**		Carp		Bass		*Lepomis*	
	Av.	No. Fish	Av.	No. Fish	Av.	No. Fish	Av.	No.Fish	Av.	No. Fish
Sta. 1F	3.6	3	5.0	7	3.5	3	1.8	5	1.8	16
Sta. 2F	18.0	3	7.1	3	--	--	15.2	3	--	--
Sta. 3F	4.4	4	3.0	4	--	--	8.4	3	2.0	7
Sta. 4F	0.9	1	14.1	2	2.5	2	1.4	2	4.0	6
Sta. 5F	0.4	1	0.3	3	--	--	--	--	0.5	5
Sta. 7F	48.3	2	24.0	3	7.5	1	--	--	2.1	1
Sta. 8F	--	--	--	--	--	--	5.6	6	--	--
Sta. 9F	--	--	--	--	3.1	5		5	1.6	11

**Sucker values include white sucker and redhorse. Catfish values include catfish and bullheads.

Table 7. Percentage of Fish. Tissue Samples Containing the Different Types of Aroclors.

Aroclor	Basin Study Area		Roanoke River		Dan River	
1242	8 samples	14%	0 samples	0%	8 samples	35%
1248	15 samples	25%	8 samples	33%	6 samples	26%
1254	55 samples	93%	20 samples	83%	23 samples	100%
ND	1 sample	2%	1 sample	4%	0 samples	0%

It is easily observable that the Aroclor 1254 predominates in the fish tissue. In fact, it was only from Station 2F that 1254 was not detectable in any of the samples.

Of the total of 59 fish tissue samples analyzed, 15 (23%) contained PCB levels exceeding the FDA 5.0 ppm guideline. Table 8 shows a breakdown of the percentage of violations (fish exceeding the 5.0 ppm guideline) by suckers, catfish, and carp (fish generally considered to be low in the food chain), and by bass and *Lepomis* (fish generally considered to be high in the food chain).

Table 8. Percentage of Violations by Fish Type and by Area Within the Basin

FISH		Kerr Lake	Leesville Lake	Roanoke River	Dan River
Suckers, catfish,	No. of samples	5	3	6	11
	No. of violations	1	1	6	2
	% of Violations	20%	33%	100%	18%
Bass and *Lepomis*	No. of samples	7	6	8	12
	No. of violations	0	0	2	3
	% of Violations	0%	0%	25%	25%

DISCUSSION

It is obvious that a trend toward higher levels of PCB contamination of both sediment and fish samples is developing as one proceeds downstream. But there are inconsistencies encountered when one looks at the type of PCB found at the stations. For instance, all three stations sampled for fish and sediment in the Dan River showed Aroclor 1242, 1248, and 1254. But while 1254 dominated these fish sampling stations, a different Aroclo. dominated each sediment sampling station. Thus, in this study area, it can be seen that the 1254 is the primary type of PCB found in fish, while 1248 is the primary type found in the sediment.

Literature previously cited indicated that the less-chlorinated PCBs are more toxic to fish than the higher-chlorinated PCBs. It is not known whether absorption of the less-chlorinated compound is killing fish (thereby eliminating these fish from sampling) or if there is an ichthyological selectivity for the higher-chlorinated PCBs. The literature available to the author has indicated that presently little is known of the biodegradation of PCBs.

Violations of the 5.0 ppm guideline can be found at every station except Station 5F, above the dam in Danville. The presence of PCBs in the sediment samples at this station indicates that PCB is there, but that most of the contaminant is in the second inch of the sediment sample.

The percentage of violations at a station increases as one proceeds downstream toward the lake, where the percentage of violations declines abruptly. The lower concentrations of PCB in the fish tissue samples at Station 1F could be indicative of a lesser degree of environmental contamination. Station 1F is at least 25 miles downstream from either Station 2F or 3F. It is possible to speculate that the PCB, because of its high specific gravity (1.3-1.5) and its insolubility in water, could be settling out in the upper portions of the lake.

SUMMARY

The study presently in progress was prompted by the apparently high levels of PCB found through routine pesticide monitoring of fish tissue in parts of the Roanoke Basin in June of 1971.

The family of compounds known as PCBs (Polychlorinated Biphenyls) has widespread use, primarily because of its inert nature. Structurally PCBs are basically similar to DDT, and both have been shown to be subject to biological magnification.

Bottom sediment samples (top three inches by 1-inch increments) and edible tissue fish samples (by fish type, e.g. suckers, catfish, carp, bass and *Lepomis*) were collected to study the level of contamination. Thus far, the fish that are higher in the food chain (bass and *Lepomis*) have not shown higher levels of PCB than those lower in the food chain, but oppositely, have actually shown lower levels of PCB.

There appears to be to a certain degree a biological selectivity for one type of PCB, the 1254 being the dominant type in the fish tissues, while the 1242 and 1248 dominate the sediment samples. Of the 59 samples (representing 119 fish) analyzed thus far, 58 have shown detectable levels of PCB. A person stands a 57% chance of catching a fish in the Roanoke River study area that exceeds the FDA 5.0 ppm (edible tissue) guideline, while in the Dan River in the study area the chance is only 22%.

More fish sampling will be done in the future in an attempt to further ascertain the degree of PCB contamination. But from the data collected thus far it is safe to say that contamination exists in the Roanoke River from below the Leesville Dam to at least the upper limits of the Kerr Reservoir. Similarly, a contamination (or at least the potential for contamination) of lesser gravity exists in the Dan River from below Danville to at least the upper limits of the Kerr Reservoir.

There is a large amount of information yet to be acquired in this study. Is there biological selectivity for the different Aroclors? Is there biological degradation of the Aroclors (or possibly reverse degradation) 1242-1248-1254? Why is the PCB in sediment largely of one type? Why is the PCB in the fish tissue a different type from that in the sediment? Does a situation exist in the Roanoke-Blackwater Rivers - Smith Mountain Lake area similar to that in the Roanoke-Dan Rivers - Kerr Lake area? These are just a few of the many questions remaining to be answered.

In order to determine the source of PCB it is necessary to sample industrial and municipal effluent. Some samples have been collected in the vicinity of Altavista, Brookneal, Halifax, South Boston, and Danville and sampling trips are scheduled for the Dan River basin in the immediate future to sample the remaining effluents below the dam in Martinsville to determine if there may be a problem in that area.

In addition, whenever it is possible to schedule shocking trips, fish collections will be made to supplement those already collected and analyzed.

If necessary, analysis of aquatic algae and benthics will be used in an attempt to define the source of PCB.

LITERATURE CITED

Duke, T.W. 1971. PCB Newsletter, U. S. Environmental Protection Agency. Nat. Water Quality Lab, Deluth, Minn, 28 July: 17-18.

Duke, T.W., J. I. Lowe, and A. J. Wilson. 1970. A Polychlorinated Biphenyl (Aroclor 1254) in the Water, Sediment, and Biota of Escambia Bay, Florida. Bull. Environ. Contam. Toxicol. 5: 171-180.

Food and Drug Adminstration. 1972. Polychlorinated Biphenyls. Notice of Proposed Rule Making. In Federal Register, March 18, 1972; 37 F.R. 5705.

Gustafson, C. G. 1970. PCBs - Prevalent and Persistent. Environmental Science and Technology. 4: 814-819.

Kiel, J. E., L. E. Preistee, and S. H. Sandifer. 1971. Polychlorinated Biphenyl (Aroclor 1242): Effects of Uptake on Growth, Nucleic Acids, and Chlorophyll of a Marine Diatom. Bull. Environ. Comtam. Toxicol. 6: 156-59.

Kroner, R.C. 1971. PCB Newsletter, U. S. Environmental Protection Agency. Nat. Water Quality Lab. Deluth, Minn. 28 July: 7.

Peakall, D. B. and J. L. Lincer. 1970. Polychlorinated Biphenyls - Another Long-Life Widespread Chemical in the Environment. Biosci. 20: 958-64.

Stallings, D.L. 1971. PCB Newsletter, U. S. Environmental Protection Agency. Nat. Water Quality Lab. Deluth, Minn. 28 July: 13.

Veith, G. D. and G. F. Lee. 1970. A Review of Chlorinated Biphenyl Contamination in Natural Waters. Water Res. 4:265-269.